PRELIMINARY RESEARCH PROPOSAL (COE) (FY07-08)

TITLE: Investigation of adult salmon and steelhead straying in the Lower Columbia River

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STUDY CODE: ADS-00-4

PROJECT DURATION: 2006-2008

SUBMISSION DATE: August 2006

II. PROJECT SUMMARY

A. Project goals

The goal of this project is to evaluate the feasibility of using PIT-tag systems to estimate straying in large tributaries. The overarching goal is to establish PIT-tag detection in major tributaries to provide an index of straying for Columbia River Basin anadromous fish populations through the Federal Columbia River Power System (FCRPS).

B. Objectives/Hypotheses

The main objective of this project is to install a prototype PIT-tag system into one site near McDonald Ferry on the John Day River. This site is located in the lower reach of the river (around RM 20) and is below all of the major spawning creeks. We intend to install antenna arrays into the thalweg portion of the river at this site to monitor the section of the river where most of the salmonids will be migrating. Then with the system operating, we plan to determine detection efficiency of the multiple antenna-array design using test fish and by monitoring the passage of migrating PIT-tagged adult salmon and steelhead. These migrating tagged salmonids might include some straying individuals, but that will not be the focus of the project until the following year. If possible, we will use a DIDSON camera to ascertain the vertical distribution of the migrating fish in the thalweg (this will help us find out what proportion of tagged fish is close enough to the crump style antennas to get detected).

Another objective of this project is to assist in the development of a new PIT-tag transceiver for stream applications. This is a tool that is critical for this project to reach its goal of installing an antenna system that can span the entire river.

C. Methodology

The first task to be completed in 2007 will be to obtain the necessary permits for installing the land-based equipment and the antennas. At the chosen McDonald Ferry site, we would like to install three arrays of antennas to infer travel direction and to increase overall tag-detection efficiency of the PIT-tag system; however we will need to get permission from the private landowners for the lower location. The second task will be to design the antennas for the final site. Antenna design will vary depending on substrate type, water depth, water velocity, and amount and type of boat activity. We plan to consult with a hydraulic engineer to ensure that the final design minimizes the amount of scouring caused by the antennas. The antennas that will be deployed will then need to be fabricated and the rest of the equipment procured (e.g., transceivers, thermoelectric generator). The PIT-tag system will be installed during the summer of 2007 when water levels are minimal. Once the system is operating under normal flow conditions, we will use test fish to determine the tag-reading efficiency of the two-antenna array design. We will also use a DIDSON camera to ascertain the vertical distribution of the migrating fish in the thalweg. We will then continue to operate and maintain the system in order to monitor passage of migrating PIT-tagged adult salmon and steelhead. If necessary, adjustments will be made to the system.

The specific tasks for this proposed project in 2007 are:

1. Finish obtaining necessary permits
2. Finish development of large antennas for chosen location
3. Write contract for assisting in development of stream transceiver
4. Statistical analysis of subsample approach
5. Procure necessary equipment for the PIT-tag detection system
6. Deploy the PIT-tag system into the chosen location
7. Determine detection efficiencies in the field with test fish
8. Ascertain vertical distribution of migrating fish in the thalweg with DIDSON camera
9. Operate and maintain the system in order to monitor passage of migrating PIT-tagged adult salmon and steelhead
10. Final report

D. Relevance

In the Final Updated Proposed Action (UPA) for the FCRPS Biological Opinion Remand released in 2004, the Action Agencies discuss needing data from RM&E efforts for determining success in meeting the hydrosystem performance standards (e.g., monitoring adult fallback and delays to help in estimating adult survival rates). Straying is one component in helping to monitor adult fallback and delays needed to help in estimating adult survival rates.

If we go back to the biological opinion (BiOp) developed by National Marine Fisheries Service (NMFS) in 2000, justification for the development of tributary PIT-tag detection systems is found principally within RAs 192, 193, and 199. These actions address the use of PIT-tagged adult salmon and steelhead to provide critical passage information with minimal adult handling mortality. Research action 193 specifically states:

The Action Agencies shall investigate state-of-the-art, novel fish detection and tagging techniques for use, if warranted, in long-term research, monitoring, and evaluation efforts.

Development of PIT-tag detectors in Columbia River tributaries will provide some of the data necessary to evaluate a range of actions including: transportation effects (RA 48), adult survival (RA 107), and indirect prespawning mortality of adult upstream-migrating fish (RA 118).

III. PROJECT DESCRIPTION

A. Background

NMFS in accord with Endanger Species Act (ESA) procedures has developed BiOps for the FCRPS. In 2004, the U.S. Army Corps of Engineers (Corps), Bureau of Reclamation, and Bonneville Power Administration (BPA) released their Final UPA for the FCRPS Biological Opinion Remand where they outlined measures to meet the performance standards described in the NMFS 2000 BiOp for the FCRPS and to meet the new jeopardy analyses proscribed by the court.

As part of collecting RM&E data to help the Action Agencies determine whether they are meeting hydrosystem performance standards, the UPA calls for monitoring adult fallback and delays to help in estimating adult survival rates. Straying is a key component in adjusting adult survival estimates. The only straying data collected on known-origin salmonids (fish PIT-tagged as juveniles) was done by the University of Idaho and NMFS between 2000 and 2003. Based on around 3,000 double-tagged salmonids, this radiotelemetry study identified the Little White Salmon, White Salmon, Deschutes, and John Day Rivers as the streams that have the highest straying rates for salmonids (Keefer et al., 2004).

Currently, models to estimate adult survival rates are using mean straying values derived from the radio-telemetry data as correction factors. However, the statistical strength of these correction factors is weak as data were collected for only a few years and only a low number of radio-tagged fish strayed. Furthermore, set correction factors will not reflect any annual variation that will naturally be occurring. In addition, recent radio-telemetry and PIT-tag data indicate there may be a relationship between being transported as a juvenile smolt and an increased propensity to stray and fallback. Consequently, regional biologists and resource managers are interested in learning more about straying rates of particular salmonid populations.

One approach that would yield annual variability for many different salmonid populations would be to develop a PIT-tag detection system for the identified tributaries with high rates of straying listed above. For the same time period as the above radiotelemetry study (2000-2003), approximately 23,000 PIT-tagged adult Chinook salmon and steelhead were detected at Bonneville Dam; therefore, tributary PIT-tag detection systems could provide information for a broad range of ESUs as every returning PIT-tagged adult would have the potential to be detected compared to the limited number of fish that are radio tagged. Moreover, an annual PIT-tag monitoring program is also cost effective because it utilizes fish tagged previously as juveniles as part of a variety of projects and eliminates the need for collection and tagging of adults during their upstream migration.

Because of advancements in PIT-tag technologies since 2000, the development of a PIT-tag detection system to monitor movement of known-origin adult salmon and steelhead into a large tributary has become a viable solution. The Corps and other agencies agreed to initiate a project in 2006 to evaluate the feasibility of developing a PIT-tag detection system for monitoring straying in a major tributary. During the first year of this project, we conducted site surveys to evaluate potential installation sites (e.g., thalweg position, land ownership, power access, substrate, etc.) and worked on increasing the size of antennas that could be installed with the FS1001M transceiver manufactured by Digital Angel. The main objectives for 2007 are to

install a prototype PIT-tag system at one location on the John Day River and to assist in the development of a new transceiver for stream applications.

Potential sites on the Deschutes and John Day Rivers were surveyed in June 2006. With its high base flow, an in-stream PIT-tag detection system on the Deschutes River appeared too challenging with the currently available PIT-tag technologies. Three sites on the John Day River were investigated: McDonald Ferry, Cottonwood Bridge, and Clarno Bridge (Fig. 1) (Anglea et al. 2006). A site adjacent to Clarno Bridge was considered the most promising during the initial survey for a prototype PIT-tag system. This was based on access to power, access to communication infrastructure, and river gradient and width. Recent discussions with the District Fish Biologist for ODFW (Tim Unterwegner) indicated that a significant amount of steelhead spawning occurs below Clarno Bridge in the Thirtymile, Grass Valley Canyon, Hay, and Rock Creeks. Based on this discussion and review of additional literature, an additional site survey was conducted in August 2006 to investigate sites near McDonald Ferry. The August survey was completed when water levels were minimal and therefore we could collect information on substrate type and thalweg location that were not possible in June. Unless information gathered during the last quarter of the fiscal year identifies a show-stopping obstacle, we plan to install a prototype system at a location around 1 mile downstream of the river ford at McDonald Ferry. Because of the possible development of a new multiplexing transceiver in the near future (1-2 years depending on funding), we decided to modify our original plans to install PIT-tag systems into two sites on a tributary and to initially only install into one site.

B. Project objectives

The goal of this project is to evaluate the feasibility of using PIT-tag systems to estimate straying in major tributaries. In 2007, the main objective of this project is to install a prototype PIT-tag system into one location on the John Day River. Then with the system operating, we plan to determine detection efficiency of the multiple antenna-array design using test fish and by monitoring the passage of migrating PIT-tagged adult salmon and steelhead. These migrating tagged salmonids might also include some straying individuals, but that will not be the focus of the project until the following year.

Another objective of this project is to assist in the development of a new PIT-tag transceiver for stream applications. This is a tool that is critical for this project to reach its ultimate goal of installing an antenna system that can span the entire river.

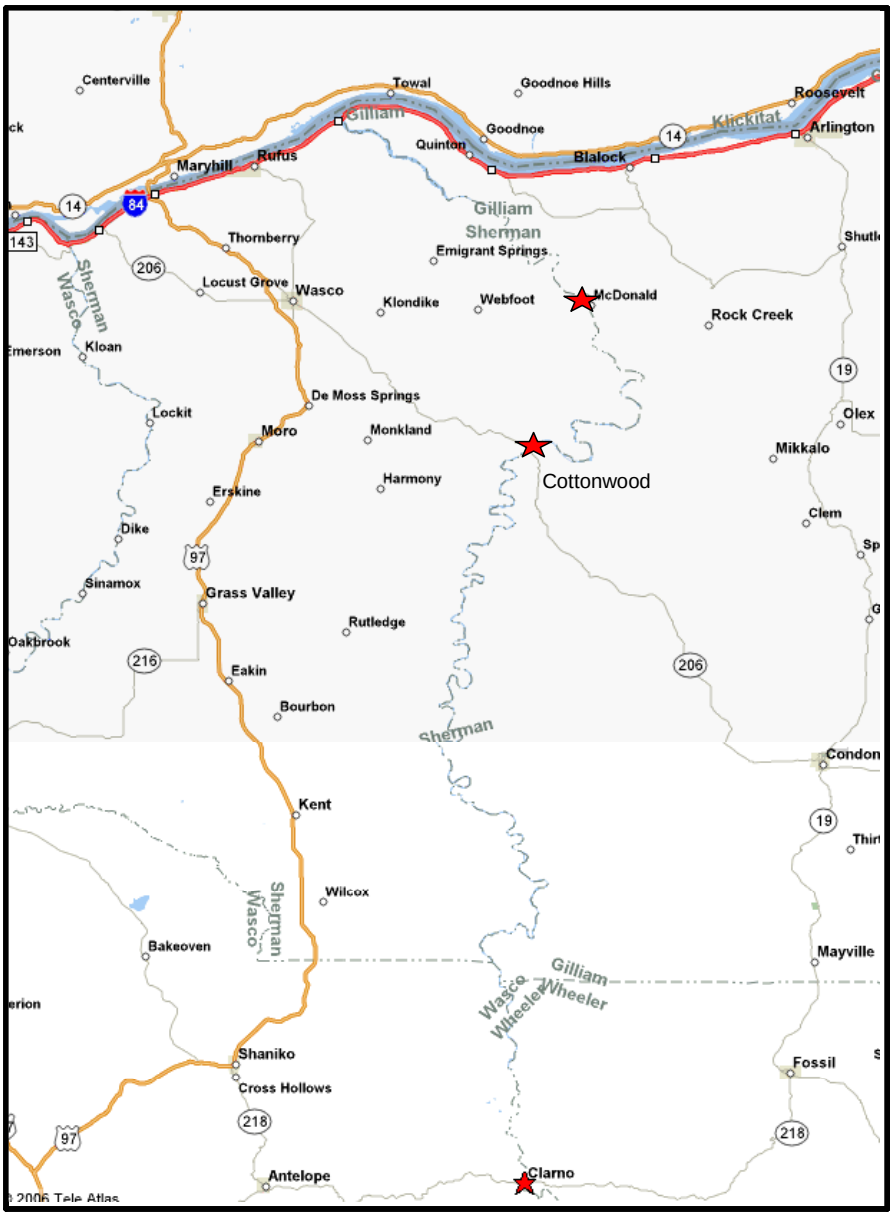

Figure 1. Map showing the sites (red stars) visited on the John Day River.

C. Methodology

At the chosen site near McDonald Ferry on the John Day River, we plan to install three antenna arrays in the thalweg portion of the river (two in downstream location and another array in the upstream location) (Fig. 2). This antenna arrangement will allow researchers to infer travel direction and increase the overall tag-detection efficiency of the PIT-tag system. Because the maximum antenna size is limited by the current transceiver technology to lengths of 25', we recognize that the installed system will not cover the entire span of the tributary. However, the chosen site will allow us to monitor the entire width of the thalweg section of the river. We plan to use crump-weir antennas, which will permit excellent coverage of the bottom section of the thalweg where we believe most adult salmonids will be traveling (Fig. 3). However, detection will not be possible in the upper half of the thalweg during high-water conditions. Since we will be subsampling the river; we plan to use statisticians to help us determine how to expand the data we collect to give statistically meaningful estimates of straying. To assist with this effort, we plan to use a DIDSON camera to ascertain the vertical distribution of the migrating fish in the thalweg. DIDSON cameras will work under muddy river conditions when the fish are migrating and normal video cameras cannot function. During the last quarter of FY06, we will have started the process of obtaining the necessary permits for installing antennas into the rivers and the land-based equipment, but the process will be completed in FY07. Once the detection system is installed, we will need to evaluate how effective it is (i.e., how well it detects passing PIT-tagged fish). Details are provided below on the approach we plan to follow.

In order to be able to reach our overarching goal of establishing PIT-tag detection in major tributaries to provide an index of straying for Columbia River Basin anadromous fish populations through the Federal Columbia River Power System (FCRPS), we need to develop a PIT-tag transceiver that will allow us to control more than six antennas in a multiplexing system. Digital Angel, the manufacturer of the different transceiver models used by the fisheries community, has outlined a plan for developing a new transceiver for stream applications. NOAA Fisheries is very interested in using such a transceiver for monitoring restoration projects and thus is planning on supporting the development effort. However, they do not have the funds for the entire development. We are requesting funds to supplement their efforts.

The specific tasks for this proposed project in 2007 are:

1. Finish obtaining necessary permits
2. Finish development of large antennas for chosen location
3. Write contract for assisting in development of stream transceiver
4. Statistical analysis of subsample approach
5. Procure necessary equipment for the PIT-tag detection system
6. Deploy the PIT-tag system into the chosen location
7. Determine detection efficiencies in the field with test fish
8. Ascertain vertical distribution of migrating fish in the thalweg with DIDSON camera
9. Operate and maintain the system in order to monitor passage of migrating PIT-tagged adult salmon and steelhead
10. Final report

Figure 2. Photos of the site near McDonald Ferry on the John Day River. This site located at around RM 20 and we would install antenna arrays at two locations separated by around 0.5 miles. We plan to install two antenna arrays in the thalweg portion of the river in downstream location (left photo) and another array in the upstream location (right photo).

Figure 3. Photo shows the crump-weir antenna array installed into the Tucannon River by Biomark. In this photo, there are three crump-weir antennas (each one is only 6’ long).

Task 1 (permits)—The duration of the process for obtaining all of the required permits varies with each project. If we have not finished obtaining the necessary permits for the selected site, then this will need to be completed in FY07. We know we will need to obtain the necessary permits for installing structures into rivers, but we may also need permits for installing structures on the river bank or onto a bridge structure.

Task 2 (finish development of larger antennas)—The scale of the candidate tributaries dictates that antenna research and development is a primary component of the project. Digital Angel introduced a new PIT tag (model TX1400SST) in 2006 which was specifically designed to be detected in the large antenna for the corner collector at Bonneville Dam. Most juvenile fish outmigrating in 2007 will be tagged with this model. Although, these fish will not return for several years, the improvement in tag technology will permit larger antennas to be designed. Currently (July 2006), the largest pass-through antenna geometry that we have constructed for the current 12-mm PIT tag (model TX1400ST) is 4' x 20'; we have had intermittent success with 4' x 25'.

The substrate at the chosen site consists of large cobble (most rocks not larger than 8"). This will mean that holding structures will be an issue during high-water conditions. We have selected the crump-weir style antennas for this installation because they can be held in position better than hybrid or pass-through antenna designs. We are currently working on developing a 2' x 25' crump-weir antenna with a flat section on top. Since we are concerned with this substrate type that scouring of the streambed will occur, we plan to consult with a hydraulic engineer to find out if there are modifications we can make to the design to reduce the scouring. Antenna durability and maintenance cost will also be key elements of antenna design. Antenna research will continue at both NMFS and Biomark facilities.

Antenna performance will be characterized in the laboratory by inserting a PIT tag into a plastic rod and measuring the reader efficiency at systematic intervals within the antenna field. Reader efficiency measurements are taken with the tag oriented at 0 degrees (best case), 45 degrees in four directions, and 90 degrees in 2 directions to the antennas vertical plane. Each tag orientation is evaluated using the tag efficiency feature of the reader from the center line (length/width) of the antenna until the efficiency is 0%. The tag efficiency feature of the reader attempts to read the PIT tag 100 times and returns the percentage of the actual number of reads for each period. Due to the fact that straying salmonids might be tagged with a number of different tag models, antenna performance will be characterized using TX1400ST and TX1400SST tags.

Task 3 (stream transceiver)— In July 2006, Digital Angel met with the fisheries community and proposed a modular design for a new transceiver for stream applications; however, no funding has been procured for the development effort at this time. NOAA Fisheries is very interested in using such a transceiver for monitoring restoration projects and thus is planning on supporting the development effort. However, they do not have the funds for the entire development. We are requesting funds to supplement their efforts. This future stream transceiver will minimally handle 12 antennas, which would enable us to cover the entire span of most of the targeted tributaries.

Task 4 (statistical analysis of subsample)— Although, this system will be only monitoring a subsample of the fish migrating upstream; it is important to remember that even a system that spanned the entire river would not be 100% efficient (i.e., it would still miss tagged fish). We have done some preliminary consultation with statisticians about the usefulness of the data that will be collected. COMPASS modelers are still focused on developing the model for the juvenile life stages and so have not figured out how they will be incorporating this data. Others want information on how well the system detects the double-tagged test fish as well as any tagged fish that are detected upstream by other projects (there is a screw trap on the John Day River where all trapped fish will be scanned and ODFW conducts spawning ground surveys where dead fish are identified as wild or hatchery strays). Most of the statisticians thought that it will be possible to come up with an expansion scheme. We will continue our discussions with them during FY07 as more is learned about the installed system.

Task 5 (procure equipment)—A PIT-tag detection system includes the antennas, transceivers, power system, and a data-communication system. Since this is a prototype system, we have decided to install a thermoelectric generator. This will avoid the high cost of bringing AC power to the site and give us flexibility if we need to move the antenna arrays for any reason. We plan to use one transceiver for each location – this will provide some redundancy if for some reason a transceiver fails. There are also different methods of transmitting data such as phone-line, satellite modem, or using a wireless transceiver. We will consult with PSMFC on their preference for this site. Once we have the details of the system, the appropriate equipment will be procured. Since hydrologic variables are already collected at McDonald Ferry, there is no need to install equipment for measuring water temperature and flow at this site. We want to collect these data because these hydrologic variables are often correlated with fish migration patterns.

Task 6 (deploy the PIT-tag detection system)—Due to safety issues related to high water levels, we plan on installing the systems during the summer of 2007. Installation of the system at this time should still provide detections of steelhead that enter in late September. We want to reiterate that the detection system we envision will have three sets of antenna arrays installed at two locations at the chosen site. The deployment will involve not only installing the antennas, but also the thermoelectric generator, transceivers, and data-communication system. All of the data will be uploaded into the regional PTAGIS database (PSMFC will assist in designing and installing the data-communication system).

Task 7 (detection efficiencies in the field)—As part of the straying detection systems, we need to be able to evaluate how effective the antennas are at detecting migrating PIT-tagged fish. We propose to investigate antenna performance using double-tagged fish (fish with both radio and PIT tags). Double-tagging fish has been used in the past, but recent evidence suggests that when the two tags are in close proximity, PIT-tag detection efficiency can be reduced. We will be conducting a laboratory investigation to determine the effect of having radio (different types) and PIT tags in close proximity to each other in September.

If double-tagging proves successful in the laboratory, we propose to double tag adults that have entered a hatchery or trap in the tributary upstream of the antenna locations. Collecting fish that have already ascended the focus tributary would be more efficient than collecting and tagging known source fish at a dam (i.e., Bonneville Dam). Collected fish would be returned to the tributary some distance below the antenna arrays. Radio-telemetry receivers would be positioned at the point of release and also at each PIT-tag array to monitor passage and evaluate performance of the individual PIT-tag array and the entire system (all three arrays combined). We estimate that a minimum of 100 double-tagged fish would need to pass through the array to determine detection efficiency (John Skalski, personal communication, University of Washington).

If we cannot use double-tagged fish, we plan to use PIT-tagged only fish. If possible, we would again collect fish from a hatchery or hopefully be able to use inriver fish that have been tagged by another project. For example, on the John Day River, NMFS and Oregon will be tagging fish and so we could use their screw trap detections as confirmation that fish have passed our antenna arrays. Similar to the approach with double-tagged fish, we would like to take some of the fish and release them again in the river below our antenna arrays and monitor them as they re-ascend. We can then estimate reading efficiencies using detections on our antenna arrays as well as the screw trap detections.

Task 8 (DIDSON camera)—Since we cannot install PIT-tag antennas that cover the entire depth of the thalweg, we want to determine whether it is true that most of the adult fish are migrating near the bottom of the river. Unfortunately, the fish tend to move through these large tributaries when the water levels are high and consequently the rivers are muddy. Consequently, regular video cameras cannot be used to monitor fish placement. Therefore, we propose to borrow a DIDSON camera (several agencies own them) and use it to monitor the vertical distribution of the fish migrating in the thalweg. Based on the information collected, we may need to modify our antenna designs.

Task 9 (monitoring fish)—Since all of the data will be uploaded into the regional PTAGIS database, we will be able to monitor the origin of any non-test PIT-tagged fish that are detected by the detection system. In future years, we will be able to use the installed system for estimating straying rates for known source ESU or ESU surrogate fish to help in determining the success at meeting hydrosystem performance standards that are typically included in the FCRPS BiOps (2008-2010).

Task 10 (final report)—When the project is finished, we will write a final report detailing the antenna development work, the equipment installed, and how well it performed.

D. Facilities and equipment

For this project to proceed, we will be purchasing PIT-tag transceivers, large antennas, and thermoelectric generators. Each piece of equipment costs in the $3-10,000 range. Obviously, without this specialized equipment, the project could not proceed. Furthermore, we are proposing to help fund the development of a stream transceiver; it will be a critical tool for achieving the overarching goal of this project.

E. Project impacts and biological effects

Establishing fixed PIT-tag detection systems within the major tributaries will require coordination with county, state, tribal, and federal parties. We will be applying for permits from the Corps for installing equipment in a navigable river. However, we do not anticipate needing support from any Corps personnel from any of the hydropower facilities.

At this time, we do not know of any detrimental biological effects that the project will have.

F. Collaborative arrangements or subcontracts

This project brings together the two entities with the most experience in applying PIT-tag technologies to stream applications. During the first year of this project, NOAA subcontracted Biomark for certain tasks and then both worked on antenna development. By combining forces, we have been able to continue developing larger antennas. Furthermore, we have been able to evaluate the pros and cons of each site visited.

IV. KEY PERSONNEL AND DUTIES

Sandra L. Downing and Earl F. Prentice	Principal Investigators
Steve Anglea	Biomark Project Manager

V. TECHNOLOGY TRANSFER

Information acquired from the proposed work will be transferred to the fisheries community by presentations at meetings and workshops, by personal contact, by annual and final reports to the Corps, and through scientific publications.

VI. REFERENCES CITED

Keefer, M., C. Peery, J. Firehammer, and M. Moser. 2004. Summary of straying rates for known-origin adult Chinook salmon and steelhead in the Columbia/Snake hydrosystem. Letter report to the U.S. Army Corps of Engineers.

Anglea, S., E. Prentice, and S. Downing. 2006. Investigation of straying in adult salmon and steelhead (Study Code: ADS-00-4). Report on Site Visits to the John Day River and Deschutes River. Letter report to the U.S. Army Corps of Engineers.

BUDGET

A detailed budget will be provided if full proposal is requested.